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Bureau of Agricultural and Industrial Chemistry
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A

REPORT OF STUDIES ON UNIFORMITY OF QUALITY OF SUGARS

I. Chemical and Physical Studies on Beet Sugars of the 1944 Campaign
By C. A. Fort and S. Byall

II. Biological Studies of Sugars
By H. H. Hall and Dorothea J. Teunisson

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PREFACE

Through the continued cooperation of the beet sugar companies and the operating personnel of their factories there were received composite samples of sugars from each of the 65 domestic factories operated during the 1944 campaign. These sugars have been examined chemically, physically, and biologically. Four additional beet sugars were included in the studies but not in the average values.

In Part I are presented (1) a summary of the operating data which were submitted along with the sugar samples, (2) the chemical and physical data obtained on the sugars, (3) a discussion of the possible use of specific conductivity in determining the distribution between mineral and organic salts, and (4) adjusted specific conductivity-ash factors for sugars of individual factories. Part II includes not only the usual biological data on the sugars, but also the results of studies on the growth of molds in highly concentrated sugar solutions.

PART I

CHEMICAL AND PHYSICAL STUDIES ON BEET SUGARS OF THE 1944 CAMPAIGN

By C. A. Fort and S. Byall

A. Process or Operating Data

(1) Quality of beets and diffusion juices. (Table 1). The average sucrose in beets increased to a yet higher level than last year. An increase was experienced at 50 of the factories. Reviewing the general sucrose averages for the past thirteen years, including 1944, there appears to be a recurrence of high sucrose each fifth year. The annual national averages from 1932 to date, are as follows:

Year	Sucrose
1930	--
1931	--
1932	16.38
1933	16.50
1934	16.60
1935	15.87
1936	15.73
1937	16.06
1938	16.09
1939	16.39
1940	15.80
1941	15.75
1942	15.40
1943	16.40
1944	16.85

The average diffusion juice purity also reached the highest level since our records started. An interesting point in respect to the annual sucrose and the corresponding diffusion juice purities is that they show a gradual improvement in purity for a given sucrose value. The average non-sugars associated with the sucrose steadily decrease from 1933 to 1942. Since diffusion juice is being considered, the non-sugars present are those not

TABLE 1

PROCESS DATA, NON-STEFFEN

Sample Number	Beets		Diffusion Juice		Lime Used	Soda Ash	Carbonation Alkalinities		2nd Carb'n. Temp.	pH	Thin Juice pH
	Sucrose	Purity	Brix	Purity	%	lbs.	1st	2nd	C°		
4401	15.91	86.3	10.9	87.4	2.91	--	0.085	0.024	100	--	9.0
4403	16.44	--	11.6	87.1	1.53	0	0.070	--	90	9.2	8.0
4404	17.44	--	10.7	87.0	3.50	0.01	0.061	0.015	93	9.0	9.0
4405	16.52	86.7	12.2	88.0	1.95	0.04	0.071	--	93	8.8	8.4
4406	17.95	85.3	14.4	86.3	4.05	--	0.084	0.017	102	--	*--
4408	16.99	88.5	13.4	89.4	1.75	0.25	0.080	0.019	96	9.0	8.2
4410	17.83	--	12.7	88.7	1.55	0.18	0.075	--	--	9.3	8.3
4411	16.71	--	12.9	87.1	1.54	0.19	0.097	--	85	9.5	8.2
4413	17.28	87.4	13.4	88.0	2.56	0.36	0.077	0.018	88	--	8.6
4414	17.02	85.5	14.3	87.1	2.29	0	0.065	0.019	91	--	8.4
4415	15.66	85.6	13.2	86.0	2.08	0.07	0.076	0.022	96	8.8	8.4
4416	17.42	86.3	14.1	87.4	2.72	0.01	0.075	0.016	104	--	8.4
4417	15.58	--	13.0	87.0	2.98	0.29	0.075	0.020	98	9.3	8.8
4418	17.18	87.0	12.2	88.8	4.47	0	0.087	0.017	95	--	8.8
4421	17.02	86.5	13.8	87.4	2.19	0	**	--	99	8.8	7.8
4422	17.62	--	12.1	87.6	1.39	0	0.073	--	88	9.3	8.1
4423	17.34	82.5	12.1	83.3	3.35	0.58	0.098	--	97	8.8	8.8
4425	17.31	--	12.0	88.3	1.26	0.28	0.074	--	--	9.4	8.0
4427	17.54	80.7	11.3	85.1	3.48	1.55	0.075	0.021	97	8.9	8.9
4429	16.90	85.1	13.1	86.9	2.59	0.54	0.073	0.017	95	--	8.1
4432	17.58	--	11.9	88.3	1.46	0.30	0.083	--	--	9.5	8.1
4433	15.15	--	11.1	86.0	5.29	0	0.070	0.017	90	--	7.8
4435	17.52	--	13.0	86.7	1.89	0	0.072	--	94	9.1	8.4
4437	17.39	88.7	13.3	90.0	3.50	0.02	0.064	0.017	90	--	8.2
4439	16.46	86.2	13.6	88.2	1.90	0	0.081	--	85	8.3	7.6
4440	16.89	85.3	11.4	87.3	2.17	0.40	0.067	0.018	93	--	7.7
4443	17.44	--	12.4	88.8	1.24	0.06	0.074	--	93	9.0	7.8
4447	15.75	83.9	12.6	86.1	2.60	0	0.068	0.023	--	--	8.6
4449	17.38	88.3	12.8	89.6	2.27	0	**	--	96	9.5	7.4
4450	15.14	--	11.4	88.2	1.39	0	0.067	--	90	9.3	8.2
4452	17.17	84.7	11.4	88.5	2.50	0	--	--	93	8.8	8.8
4453	16.77	86.2	11.1	88.8	2.18	0.29	0.057	0.016	95	--	7.5
4454	16.71	87.1	12.5	88.8	2.20	0.20	0.059	0.016	94	--	7.1
4455	16.53	--	12.0	85.6	3.29	0	0.056	0.016	89	--	8.5
4459	17.73	88.0	11.9	88.2	2.53	0	0.083	--	90	8.8	7.6
4461	16.65	86.2	12.2	88.3	1.83	0.04	0.065	0.022	96	--	7.7
4463	16.69	83.1	10.9	86.8	3.53	0.69	0.087	--	94	8.9	8.9
4464	19.40	85.9	15.9	86.7	3.13	0.36	0.072	--	93	8.8	8.3
4466	17.41	89.2	11.9	89.0	2.30	0.13	0.079	0.016	98	9.1	9.0
4469	17.15	86.8	13.6	87.2	1.89	0	0.076	--	89	8.9	8.0
4473	16.93	87.2	12.4	88.7	2.14	0	0.070	0.025	93	--	9.3
4476	15.56	86.8	11.9	88.5	1.99	0.82	0.073	0.012	102	9.1	8.8
4479	16.54	86.8	12.0	88.1	2.04	0	0.078	0.016	96	--	7.3
4480	16.40	85.1	13.3	85.6	2.68	0	0.070	0.020	--	--	8.2
4482	17.42	--	12.2	88.8	1.31	0.18	0.077	--	94	9.6	8.5
4494	17.71	86.7	12.6	89.5	2.21	0	0.081	0.011	87	8.7	8.0
4496	18.54	87.3	14.6	88.4	2.84	0	0.082	0.028	83	--	8.9
Avg. 1943	16.51	--	12.6	87.2	2.14	0.14	0.074	0.017	92	9.1	8.26
Avg. 1944	16.92	--	12.5	87.6	2.43	0.17	0.074	0.018	94	9.1	8.30

TABLE 1

PROCESS DATA, STEFFEN

Sample Number	Beets		Diffusion Juice		Lime Used	Soda Ash	Carbonation Alkalinities		2nd Carb'n. Temp.	pH	Thin Juice pH
	Sucrose	Purity	Brix	Purity	%	lbs.	1st	2nd	C°		
4407	17.23	--	11.5	88.3	2.60	0.51	0.067	--	93	9.1	7.9
4420	17.85	88.6	13.2	89.3	3.01	0	**	--	91	9.2	8.7
4426	17.27	--	12.3	87.1	3.51	0.80	0.058	--	81	9.3	8.3
4428	15.30	80.1	13.5	81.6	4.86	0.07	0.056	--	--	--	8.1
4430	15.70	--	11.3	85.5	2.73	0.25	0.060	--	89	9.1	8.1
4431	16.14	85.0	13.1	86.7	3.24	0.04	0.081	0.022	94	--	8.0
4441	17.73	--	11.8	87.8	3.09	0.08	--	--	88	9.2	7.7
4442	17.68	--	11.7	88.4	3.05	0.11	0.076	--	88	9.2	8.1
4446	16.86	86.8	12.4	87.3	3.32	0.25	0.077	0.019	97	8.9	7.3
4456	16.00	--	11.4	86.0	2.47	0.81	0.064	--	87	9.3	8.3
4457	17.59	87.2	14.4	88.1	4.31	3.00	0.081	0.015	93	--	8.1
4460	17.17	88.0	11.4	89.2	3.77	0.07	0.067	--	98	9.5	7.8
4465	16.99	--	12.7	87.7	2.74	0.15	0.067	--	92	9.3	8.3
4471	17.65	87.0	14.5	88.5	3.76	0.74	0.071	--	--	9.1	8.8
4472	16.45	--	10.9	86.6	3.31	0.63	0.072	--	84	9.2	7.9
4475	16.91	84.9	12.8	86.1	3.36	0	0.065	--	93	9.4	8.4
4477	16.89	--	13.0	85.8	3.33	0	**	--	92	9.1	8.1
4478	14.65	81.9	12.4	84.0	3.47	1.69	0.080	0.017	83	--	8.7
4483	15.94	83.3	11.8	86.4	4.13	0	0.081	--	98	(8.1)	(7.7)
4484	16.73	87.3	14.3	87.5	2.63	0	0.078	--	85	8.9	8.8
4495	17.46	85.6	14.5	88.9	2.55	0.53	0.074	0.013	91	--	7.8
Avg. 1943	16.26	--	12.3	86.7	3.27	0.55	0.069	0.016	92	9.1	8.2
Avg. 1944	16.74	--	12.5	86.9	3.33	0.46	0.071	0.018	90	9.1	8.2

Non-Steffen * Alkalinity 0.007
Non-Steffen ** pH no. 4421, 10.7; no. 4449, 11.1

Steffen ** pH no. 4420, 11.1; no. 4477, 10.8
Steffen () pH at juice temperature

coagulated by the heat used during diffusion. This decrease in the soluble non-sugars in relation to sucrose could be associated with some degree of soil depletion, better agronomic methods, or better varieties. The annual diffusion juice purities and the calculated soluble non-sugars, as percent on beets, are as follows:

Year	Purity	Non-Sugars
1933	85.8	2.73
1934	85.9	2.70
1935	85.2	2.76
1936	85.4	2.68
1937	85.9	2.63
1938	86.2	2.57
1939	86.3	2.60
1940	86.6	2.44
1941	86.7	2.41
1942	86.6	2.38
1943	87.0	2.45
1944	87.3	2.45

(2) Liming and Carbonation. The lime used in non-Steffen operations (Table 1) shows a decided increase on the average. This may have been partly due to the fact that some eleven factories which were normally Steffen factories operated non-Steffen. The use of soda ash at non-Steffen factories increased very slightly. The changes were small, but the trends in respect to lime salts in standard liquor and CaO in sugars corresponded: that is, there was a decrease in the case of non-Steffen and an increase for Steffen. The carbonation alkalinities were essentially unchanged.

(3) Sulphuring. (Table 2). The average amount of sulphur used was about the same as in the previous campaign. The pH changes between thin juice and thick juice were smaller than normal, and the resulting average pH of thick juice and standard liquor was lower than usual.

TABLE 2

PROCESS DATA, NON-STEFFEN

Sample Number	Thin Juice		Thick Juice			Standard Liquor or Blow-up Filtration			Lime Salts	White Brix	Massecuite Purity	pH
	Sulphur lbs.	pH	Sulphur lbs.	pH	Purity	Brix	Aid lbs.	Temp. C°				
4401	0.20	9.0	0.14	9.0	91.2	59.3	0.66	97	0.056	91.3	92.5	8.5
4403	0.60	8.0	0	8.8	--	66.7	0.38	90	0.022	91.0	90.6	8.8
4404	0.30	9.0	0	--	--	63.0	0.93	92	0.030	91.8	89.9	8.8
4405	0.57	8.4	0	9.0	91.0	65.3	0.63	95	0.054	91.7	93.0	8.8
4406	0.20	--	0	8.4	90.8	61.5	0.60	92	0.058	92.4	92.9	8.3
4408	0.36	8.2	0	8.6	92.6	69.4	0.94	91	0.047	91.2	93.3	8.5
4410	0.53	8.3	0	9.2	--	69.2	0.38	88	0.032	91.2	91.7	9.0
4411	0.56	8.2	0.06	9.0	--	68.8	0.24	89	0.013	91.5	90.9	8.9
4413	0.07	8.6	0.30	9.2	91.6	59.6	0.69	95	0.060	91.3	92.7	8.5
4414	0.23	8.4	0	9.0	90.9	65.1	0.52	98	0.041	92.0	92.5	8.9
4415	0.45	8.4	0.09	8.3	90.8	65.4	0.64	93	0.065	91.2	92.9	7.9
4416	0.36	8.4	0	8.9	92.3	68.6	0.38	94	0.045	91.4	93.1	9.0
4417	0.28	8.8	0	8.1	91.7	66.8	0.73	88	--	91.7	94.1	8.1
4418	0.25	8.8	0.13	8.8	91.5	59.9	0.69	96	0.036	91.8	92.6	8.9
4421	0.57	7.8	0	8.3	91.6	68.1	0.67	92	0.028	91.4	93.2	8.2
4422	0.46	8.1	0	8.6	--	69.5	0.34	94	--	91.3	91.2	8.6
4423	0.10	8.8	0.10	8.8	89.2	65.1	--	92	0.075	91.8	90.9	8.6
4425	0.50	8.0	0.01	8.6	--	73.0	0.45	93	0.031	90.9	91.2	8.5
4427	0	8.9	0.30	9.1	90.8	65.9	0.71	96	0.033	90.5	92.6	8.9
4429	0.49	8.1	0	8.9	91.0	62.3	0.58	93	0.032	92.0	92.6	9.0
4432	0.53	8.1	0	8.9	--	67.3	0.51	93	0.020	91.3	91.7	8.7
4433	0.50	7.8	0	8.0	91.7	60.7	0.48	95	0.061	92.4	87.6	7.7
4435	0.40	8.4	0.10	9.2	91.1	65.4	0.38	98	0.038	92.2	91.7	9.1
4437	0.27	8.2	0	8.9	93.3	65.7	0.27	89	0.043	91.3	93.8	8.8
4439	0.41	7.6	0	8.4	92.2	67.8	0.59	90	0.056	93.6	93.9	8.6
4440	0.69	7.7	0	7.8	90.1	--	1.00	83	0.044	92.0	90.2	7.7
4443	0.53	7.8	0	8.7	91.0	69.8	0.54	87	0.025	90.7	91.6	8.6
4447	0.14	8.6	0	8.7	90.9	62.9	0.58	100	0.046	90.5	91.9	8.5
4449	0.78	7.4	0	8.2	92.7	68.3	0.66	93	0.010	92.1	93.9	8.2
4450	0.51	8.2	0	9.0	--	70.7	0.49	84	0.025	90.8	92.1	9.0
4452	0.36	8.8	0	9.6	90.2	53.6	0.58	95	0.022	92.0	88.4	8.4
4453	0.44	7.5	0	7.5	92.4	67.0	1.03	88	--	91.5	94.2	7.7
4454	0.51	7.1	0	6.8	90.7	61.5	1.11	88	--	91.8	92.2	6.8
4455	0.42	8.5	0	8.7	90.2	63.6	1.57	88	0.058	90.2	91.7	8.8
4459	0.86	7.6	0	7.7	93.0	67.8	0.45	98	0.021	90.6	92.6	7.5
4461	0.68	7.7	0	8.1	90.3	69.9	0.80	89	--	92.5	90.8	8.1
4463	0	8.9	0.25	9.4	90.9	63.4	0.77	97	0.015	92.3	91.4	8.8
4464	0.43	8.3	0	8.4	89.6	64.7	0.76	96	0.039	91.4	93.0	8.3
4466	0.15	9.0	0.15	9.4	92.5	66.3	0.41	92	0.024	91.4	93.2	8.7
4469	0.46	8.0	0	8.8	91.9	67.9	0.32	96	0.038	91.1	92.3	8.8
4473	0.20	9.3	0.46	9.8	91.5	59.6	0.40	94	0.092	91.1	93.1	8.8
4476	0.23	8.8	0	8.3	91.7	65.8	0.60	93	0.085	92.6	93.5	8.0
4479	0.61	7.3	0	7.7	89.8	61.0	0.95	90	0.009	91.8	90.8	8.2
4480	0.41	8.2	0	8.9	90.1	68.3	0.35	92	0.039	91.0	91.6	9.0
4482	0.45	8.5	0	8.7	91.1	68.8	0.32	90	0.033	91.1	91.1	8.9
4494	0.37	8.0	0	9.2	92.4	67.0	0.38	96	0.041	91.6	93.1	9.2
4496	0.38	8.9	0	9.2	92.0	63.2	0.74	92	0.041	90.1	93.8	8.7
Avg.1943	*	8.20	*	8.75	91.3	67.6	0.56	92	0.041	91.4	92.1	8.70
Avg.1944	**	8.26	**	8.64	91.2	65.5	0.62	92	0.040	91.5	92.1	8.50

TABLE 2

PROCESS DATA, STEFFEN

Sample Number	Thin Juice		Thick Juice			Standard Liquor or Blow-up				White	Massecuite	
	Sulphur lbs.	pH	Sulphur lbs.	pH	Purity	Filtration Brix	Aid lbs.	Temp. C°	Lime Salts %	Brix	Purity	pH
4407	0.49	7.9	0	8.7	91.1	68.7	0.55	92	0.029	91.0	91.7	8.7
4420	0.18	8.7	0.11	8.9	92.6	62.5	0.36	96	0.051	91.3	93.0	8.1
4426	0.48	8.3	0	8.7	--	68.1	0.88	92	0.024	90.3	91.5	8.8
4428	0	8.1	0.67	9.4	87.7	62.1	0.73	87	0.127	91.6	89.6	8.7
4430	0.61	8.1	0	8.8	90.5	71.6	0.53	85	0.034	89.8	90.7	8.8
4431	0.66	8.0	0	7.7	91.0	67.3	0.70	--	0.026	90.4	93.1	7.6
4441	0.40	7.7	0	8.1	--	68.9	0.53	98	0.040	91.5	91.8	8.3
4442	0.39	8.1	0	8.5	--	69.2	0.57	98	0.034	90.5	92.1	8.5
4446	0.72	7.3	0	7.2	91.1	69.2	0.49	88	0.041	90.4	92.8	7.8
4456	0.53	8.3	0	8.6	--	68.1	0.92	92	--	91.7	91.1	8.7
4457	0.50	8.1	0	7.5	90.7	65.8	0.55	91	0.080	90.4	93.1	7.6
4460	0.40	7.8	0	7.8	93.1	69.5	0.74	96	0.038	90.7	94.9	7.8
4465	0.38	8.3	0	8.7	--	69.4	0.50	87	0.035	89.4	91.3	8.7
4471	0.18	8.8	0	8.4	92.5	68.9	0.62	97	--	91.2	94.5	8.1
4472	0.58	7.9	0	8.5	--	69.1	0.98	91	--	92.2	90.6	8.5
4475	0.31	8.4	0.04	9.5	89.7	61.5	0.37	87	0.076	90.3	92.5	8.5
4477	0.37	8.1	0	--	--	68.6	0.26	93	0.036	90.6	91.5	8.5
4478	0.33	8.7	0	8.9	88.4	63.1	0.60	89	0.054	93.9	91.4	8.9
4483	0.17	7.7	0	8.1	90.1	60.8	0.18	95	0.130	91.5	92.7	8.0
4484	0.32	8.8	0.22	--	--	64.7	0.31	100	0.051	91.3	92.4	8.2
4495	0.36	7.8	0.12	7.7	91.0	63.3	0.40	--	0.147	90.1	90.4	7.3
Avg.1943	*	8.2	*	8.5	90.6	67.1	0.66	92	0.049	91.1	92.2	8.4
Avg.1944	**	8.2	**	8.4	90.7	66.9	0.57	92	0.053	91.0	92.1	8.3

Non-Steffen * Avg. total sulphur used 1943 0.47 lbs. per ton beets
Non-Steffen ** Avg. total sulphur used 1944 0.45 lbs. per ton beets

Steffen * Avg. total sulphur used 1943 0.45 lbs. per ton beets
Steffen ** Avg. total sulphur used 1944 0.45 lbs. per ton beets

(4) Standard Liquor and White Massecuite. (Table 2). The average density for filtration of standard liquor shows a decrease, as about one-third of the factories filtered at a Brix below 65°. This agrees with the practice in 1942. The use of filter-aid increased at non-Steffen factories but showed a corresponding decrease for the Steffen factories. At nine factories both top discharge presses and double filtration were used on standard liquor. Top discharge presses were used at an additional five factories, and double filtration at eight other factories.

White massecuite purities were unchanged with some 55% of the massecuites having above 92° purity. The yield of white sugar per cu. ft. of massecuite increased very slightly.

(5) Washing White Sugars. (Table 3). The total water used indicates a decrease in the case of non-Steffen sugars but an increase on the Steffen sugars. About one quarter of the factories used superheated water. The purity of high green sirup was normal, but the high wash purity was slightly lower than in 1943.

(6) Raw Massecuites and Remelt Sugars. (Table 4). The purity of high raw massecuite was slightly higher, and the quantity of massecuite per 100 lbs. of white sugar was lower. The raw sugar purities decreased except for the Steffen low raws, which improved in purity.

(7) Storage of Beets. Nearly one-third of the beets sliced had been in storage piles for an average of roughly thirty days. Basic and practical studies of reduction in storage losses are being continued at Salt Lake City. A paper recommending whitewashing of the surfaces of storage piles to reflect the sun's heat and thus reduce beet temperatures and lower respiration losses has been submitted for publication.

TABLE 3

PROCESS DATA, NON-STEFFEN

Sample Number	White Massecuite				White Sugar as sacked		High Green		High Wash	
	Cu. Ft. per 100 lbs. sug.	Wash Water Temp. C°	Wash Water Qts. per machine	Wash Water Qts. per 100 sug.	Temp. C°	Moisture %	Brix	Purity	Brix	Purity
4401	6.50	87	16.0	6.4	47	0.039	64.2	84.3	69.5	89.8
4403	3.22	90	16.0	3.5	39	0.021	77.5	83.8	--	90.4
4404	2.49	105	7.2	2.1	49	0.031	60.2	79.1	59.0	86.8
4405	2.90	95	17.0	6.0	49	0.032	65.7	87.5	--	92.7
4406	2.85	115	14.0	--	--	0.030	--	87.0	--	92.3
4408	3.25	95	17.0	4.5	46	0.046	68.8	88.1	74.5	91.3
4410	3.20	95	18.0	7.0	35	0.010	77.8	85.0	82.0	89.4
4411	2.80	92	13.0	5.5	38	0.018	73.7	83.8	--	90.6
4413	2.89	120	15.0	5.0	45	0.039	83.4	85.5	77.4	91.5
4414	2.94	100	20.0	8.0	50	0.026	70.5	86.1	--	90.7
4415	2.88	110	17.0	4.4	42	0.029	75.2	86.7	73.8	93.9
4416	2.92	107	13.0	3.0	52	0.047	69.8	87.1	--	90.5
4417	3.03	91	16.0	4.6	43	0.016	70.2	89.4	70.3	94.3
4418	2.70	123	11.9	3.1	43	0.012	63.2	85.2	77.3	92.9
4421	2.80	98	16.0	4.6	43	0.033	77.4	86.8	--	--
4422	2.97	94	16.0	5.6	41	0.022	73.5	81.3	--	89.1
4423	2.79	--	13.0	6.0	42	0.033	82.0	84.7	--	88.6
4425	2.83	94	18.0	7.4	43	0.020	--	82.6	--	89.4
4427	2.55	98	12.5	4.2	40	0.019	65.0	85.3	65.0	89.8
4429	2.58	115	15.0	4.9	32	0.035	70.4	86.7	--	92.3
4432	2.89	91	16.0	--	34	0.015	72.5	84.2	--	91.7
4433	3.16	100	20.0	--	--	--	65.0	76.1	--	83.1
4435	3.10	94	12.0	4.1	62	0.023	74.3	84.3	76.2	92.1
4437	3.90	109	14.0	4.0	38	0.022	69.6	87.9	70.0	93.6
4439	3.36	95	14.5	3.6	59	0.034	71.0	88.2	69.4	92.3
4440	3.07	93	15.0	8.0	59	0.026	73.2	83.5	79.0	86.9
4443	3.45	92	18.0	5.5	40	0.026	77.5	85.8	--	89.6
4447	2.15	105	13.0	2.1	39	0.029	--	85.8	--	91.5
4449	2.82	88	17.0	5.7	55	0.035	76.1	87.3	--	92.8
4450	2.98	96	17.0	6.0	42	0.027	76.7	84.6	--	90.6
4452	--	92	17.0	--	--	--	83.5	76.1	59.0	84.7
4453	2.53	92	16.3	--	55	0.021	73.2	87.4	--	--
4454	2.22	91	13.1	--	41	0.032	72.9	83.8	--	91.0
4455	3.10	90	12.0	--	--	0.068	--	86.0	--	91.0
4459	2.84	92	11.8	3.7	55	0.047	--	84.9	--	92.7
4461	2.71	94	15.1	3.9	44	0.027	73.3	83.5	--	91.1
4463	2.84	98	13.5	4.6	54	0.038	84.9	83.6	72.0	90.7
4464	2.78	94	16.0	5.6	41	0.032	--	84.7	--	91.5
4466	2.94	125	15.0	3.9	41	0.021	74.3	86.5	77.9	92.5
4469	2.81	93	15.0	5.2	57	0.031	76.5	86.4	69.6	90.3
4473	2.63	98	14.9	4.6	44	0.026	80.1	87.0	78.2	93.0
4476	3.08	100	15.0	5.0	51	0.021	66.9	87.5	--	93.6
4479	3.36	90	13.0	--	42	0.031	80.3	84.4	--	--
4480	3.02	110	17.0	--	52	0.034	70.9	85.4	--	91.3
4482	2.83	90	17.0	7.5	35	0.019	75.3	83.7	--	89.2
4494	3.02	118	13.4	4.5	36	0.028	81.0	85.1	75.5	91.7
4496	2.98	75	8.0	3.9	43	0.029	--	86.2	--	90.8
Avg. 1943	2.94	97	15.7	5.0	46	0.027	--	85.1	--	91.0
Avg. 1944	2.99	99	15.1	5.0	45	0.029	--	85.0	--	90.8

TABLE 3

PROCESS DATA, STEFFEN

Sample Number	White Massecuite				White Sugar as sacked		High Green		High Wash	
	Cu. Ft. per 100 lbs. sug.	Wash Water					Brix	Purity	Brix	Purity
		Temp. C°	Qts. per machine	Qts. per 100 sug.	Temp. C°	Moisture %				
4407	3.05	96	16.0	5.7	36	0.024	75.9	85.5	--	89.1
4420	3.14	94	15.0	5.9	54	0.027	81.7	87.1	79.4	90.9
4426	3.50	97	17.0	6.5	32	0.021	76.3	84.6	--	90.4
4428	3.60	90	16.0	6.5	45	0.044	81.0	82.7	76.9	89.2
4430	3.30	86	16.0	5.7	40	0.032	77.1	84.4	--	88.3
4431	2.85	98	16.0	5.1	62	0.033	76.3	85.7	66.1	94.1
4441	2.72	101	17.0	5.3	38	0.018	76.4	83.1	--	89.3
4442	2.83	85	17.0	--	45	0.022	77.3	86.5	--	92.1
4446	3.27	96	16.0	--	51	0.040	79.9	86.3	76.0	92.1
4456	3.21	90	14.0	5.5	34	0.016	71.5	85.1	--	90.9
4457	2.88	97	17.0	5.4	58	0.029	75.3	87.5	--	--
4460	--	115	16.0	--	43	0.030	70.5	88.9	68.5	95.3
4465	2.72	90	18.0	5.9	42	0.045	75.8	84.6	--	89.5
4471	3.09	95	15.3	--	44	0.036	75.0	89.6	--	--
4472	3.36	95	14.0	5.9	40	0.020	77.1	82.8	--	89.2
4475	3.29	95	16.0	6.7	48	0.045	74.8	85.6	71.6	92.1
4477	2.83	97	16.0	4.4	60	0.037	79.2	85.0	--	90.2
4478	2.96	94	--	--	42	0.023	--	85.0	--	90.8
4483	2.76	98	22.6	5.7	24	0.023	75.0	87.1	--	--
4484	2.85	95	19.0	7.7	58	0.029	71.2	85.7	67.7	91.7
4495	3.33	112	18.1	6.0	50	0.031	81.5	81.7	77.7	89.6
Avg.1943	3.02	97	15.5	5.3	45	0.029	--	85.5	--	91.1
Avg.1944	3.06	95	16.5	5.9	45	0.029	--	85.6	--	90.9

TABLE 4

PROCESS DATA, NON-STEFFEN

Sample Number	High Raw Massecuite			High Raw Sugar Purity	Low Raw Massecuite			Low Raw Sugar Purity	Carbon used per 100 wht. sug. lbs.
	Brix	Purity	Cu.Ft.per 100 wht. sug.		Brix	Purity	Cu.Ft.per 100 wht. sug.		
4401	92.2	84.0	1.70	96.2	92.2	77.5	1.60	95.2	0.04
4403	92.6	82.3	4.00	92.9	97.5	72.9	0.50	90.2	0
4404	--	--	--	--	92.7	78.9	0.59	94.0	0
4405	92.9	86.6	2.30	97.4	95.5	75.9	0.60	90.9	0
4406	93.5	87.0	--	98.1	94.5	76.5	--	93.8	0
4408	93.1	86.0	1.37	98.1	93.5	75.6	0.47	93.3	0.04
4410	93.6	82.2	1.35	96.6	96.8	79.8	0.50	86.3	0
4411	94.9	83.7	1.20	97.2	97.5	72.9	0.66	90.3	0
4413	91.2	83.3	1.21	97.6	92.8	77.2	0.54	94.3	0.02
4414	93.6	84.9	1.15	98.2	96.1	76.0	0.60	93.5	0
4415	92.1	86.6	1.23	99.3	92.9	77.2	0.82	94.6	0.12
4416	93.4	85.4	1.36	98.1	94.8	73.8	0.55	91.1	0
4417	92.4	89.4	1.51	99.6	94.8	78.7	0.69	97.0	0.01
4418	92.4	85.0	0.92	98.2	93.7	76.0	0.55	93.2	0.07
4421	91.8	87.0	1.14	99.5	91.9	75.9	0.61	93.7	0
4422	93.0	82.3	1.26	94.5	96.9	72.4	0.51	90.1	0
4423	91.7	84.9	1.34	96.1	90.7	76.7	0.89	91.4	0.20
4425	93.5	81.0	0.98	--	97.1	71.1	0.49	--	0
4427	91.4	85.8	1.20	98.7	93.7	76.6	0.66	94.9	0.27
4429	93.6	84.9	1.53	97.4	94.7	74.2	0.57	93.1	0
4432	93.5	84.3	1.16	98.2	97.4	73.1	0.56	88.0	0
4433	--	--	--	--	94.8	74.6	0.51	95.5	0
4435	93.5	85.6	1.13	97.7	96.2	75.7	0.61	92.1	0.02
4437	92.7	85.7	1.33	98.1	94.1	75.8	0.45	91.3	0.11
4439	92.7	89.1	1.38	97.7	93.8	78.2	0.61	93.7	0.12
4440	93.4	83.6	1.10	97.5	94.1	72.7	0.56	89.4	0.19
4443	92.5	85.2	1.26	98.3	95.1	75.9	0.51	87.7	0
4447	91.5	85.3	1.13	99.0	91.8	75.1	0.53	94.3	0.22
4449	92.0	87.3	1.05	98.4	92.5	78.0	0.57	92.7	0.09
4450	93.1	82.1	1.28	97.1	97.7	72.6	0.51	92.6	0
4452	--	--	--	--	93.0	77.6	--	91.0	0
4453	91.9	87.3	1.23	99.1	94.1	78.6	0.56	89.5	0.14
4454	92.7	83.6	1.05	96.5	94.7	74.5	0.45	89.7	0.14
4455	91.8	85.1	1.23	--	94.4	75.2	0.64	--	0
4459	92.4	84.6	1.10	97.1	95.9	73.5	0.46	89.3	0
4461	93.8	83.1	0.95	94.6	96.3	71.0	0.42	89.2	0.16
4463	94.9	83.6	1.21	97.8	92.8	75.6	0.63	93.9	0
4464	92.7	85.9	1.46	99.1	95.2	75.9	0.66	93.4	0
4466	91.7	83.9	1.47	96.3	93.8	76.2	0.44	95.2	0.02
4469	91.1	86.3	1.19	96.5	94.1	76.9	0.61	92.7	0.02
4473	93.7	84.7	1.44	98.9	98.0	75.0	0.58	90.8	0.13
4476	93.2	85.2	1.50	97.8	93.7	74.0	0.50	91.2	0.10
4479	92.9	83.2	1.44	95.8	96.0	71.6	0.50	87.5	0.14
4480	92.7	84.3	1.82	96.9	95.3	73.8	0.75	89.5	0
4482	91.1	83.7	0.86	96.3	96.5	73.6	0.52	90.1	0
4494	86.3	85.9	1.00	97.6	93.4	76.4	0.54	93.5	0
4496	91.9	86.9	0.96	95.7	94.6	77.4	0.53	93.8	0.11
Avg.1943	92.8	84.5	1.39	97.6	95.0	74.9	0.62	92.2	0.06
Avg.1944	92.7	84.9	1.35	97.5	94.7	75.2	0.59	91.9	0.05

TABLE 4

PROCESS DATA, STEFFEN

Sample Number	High Raw Massecuite			High Raw Sugar Purity	Low Raw Massecuite			Low Raw Sugar Purity	Carbon used per 100 wht. sug. lbs.	Molasses worked % beets
	Brix	Purity	Cu. Ft. per 100 wht. sug.		Brix	Purity	Cu. Ft. per 100 wht. sug.			
4407	92.6	84.3	1.35	98.0	94.5	74.9	0.57	89.1	0.03	4.37
4420	90.7	87.3	1.07	97.8	92.3	78.2	0.51	97.0	0	3.47
4426	91.1	83.4	--	97.5	94.6	74.8	--	94.2	0	6.61
4428	88.3	83.4	--	96.0	92.7	77.6	--	95.8	0.17	8.00
4430	94.2	94.3	1.50	95.9	95.0	75.1	0.76	89.4	0	5.08
4431	91.9	86.1	1.29	99.6	91.6	78.9	0.84	94.5	0.01	4.23
4441	92.3	83.2	0.96	97.2	94.2	73.4	0.52	88.2	0	5.59
4442	90.6	83.6	1.25	97.3	92.3	74.9	0.56	90.8	0	6.10
4446	91.1	87.2	1.15	99.2	91.7	78.8	0.86	93.5	0.01	6.28
4456	92.9	82.9	1.48	97.6	97.0	72.9	0.73	88.4	0.14	4.61
4457	91.3	86.9	1.74	99.7	91.6	74.9	0.81	94.5	0.15	7.56
4460	90.8	80.7	1.43	99.0	91.9	80.7	0.69	93.6	0.12	5.19
4465	91.0	83.8	1.35	96.0	93.8	74.2	--	87.6	0	4.90
4471	91.6	88.9	1.50	98.1	92.7	80.3	0.77	96.8	0	4.84
4472	91.3	81.6	1.12	95.1	95.4	75.3	0.68	92.2	0	6.34
4475	91.8	85.5	1.44	98.6	92.1	75.3	0.75	96.1	0.09	3.51
4477	92.2	85.1	1.28	96.9	93.3	74.6	0.63	90.9	0.02	4.35
4478	94.1	86.2	2.04	97.3	95.7	76.3	0.98	92.9	0	4.21
4483	92.0	86.6	1.24	98.7	92.4	79.3	0.85	96.7	0	5.40
4484	90.2	85.9	1.21	96.2	92.0	76.3	0.62	92.4	0.01	2.21
4495	91.5	82.1	0.26	97.5	91.6	78.7	0.82	92.7	0	4.48
Avg.1943	91.8	85.2	1.46	97.7	93.8	76.2	0.70	92.3	0.07	4.81
Avg.1944	91.5	85.3	1.36	97.6	93.3	76.3	0.71	92.7	0.04	5.14

B. Chemical and Physical Data on White Sugars

(1) Ash Content of Sugars. (Table 5). In order to conserve time for additional direct research, the gravimetric determination of ash was omitted. The specific conductivity was determined (on a solution of 30 grams of sugar per 100 cc.) and indicates that on the average the soluble minerals were essentially identical with 1943 sugars. The calculated carbonate and sulphate ash values shown were estimated by use of an individual conductance-ash factor for each sugar and were adjusted to the mineral composition found in respect to chlorides, sulphates, and sulphites. A more complete discussion of the means of making this adjustment will be given later, but the matter is mentioned here because it will be evident from the data presented that a uniform factor was not used. It is believed that the values found are more accurate than gravimetric testing. It should be explained further that the ash figures are for soluble ash and do not include silica or other inert insolubles. The values found in previous years indicate that in most sugars the silica is less than 10 p.p.m. and averages 6 p.p.m.

Since the annual averages for ash have not been summarized for some years it may be of interest to review them. They show the improvement which was accomplished ten or more years ago and the maintenance of quality in this respect since 1937.

Year	Carbonate Ash p.p.m.
1929	427
1930	389
1931	274
1932	245
1933	197
1934	140
1935	132
1936	135
1937	116
1938	109
1939	110
1940	100
1941	90
1942	113
1943	105
1944	105

(2) Sulphites. (Table 5). This constituent increased some on the non-Steffen sugars but not on the Steffen sugars. Roughly 75% of the sugars had less than 10 p.p.m. of SO_2, and 8% had more than 20 p.p.m. The annual averages show the same trend found in the total ash.

Year	SO_2 p.p.m.
1930	23.2
1931	25.1
1932	26.6
1933	25.4
1934	16.5
1935	13.7
1936	12.4
1937	12.4
1938	11.5
1939	9.6
1940	8.0
1941	7.5
1942	5.8
1943	7.0
1944	8.8

(3) Sulphates. (Table 5). Sulphates also increased this year, there being a considerable increase in the number of sugars with SO_3 over 20 p.p.m. The annual averages to date are as follows:

Year	SO_3 p.p.m.
1930	95.
1931	49.
1932	22.4
1933	21.7
1934	15.6
1935	--
1936	14.1
1937	15.1
1938	7.8
1939	9.3
1940	8.0
1941	7.5
1942	9.0
1943	10.7
1944	13.5

(4) Chlorides. (Table 5). This constituent decreased on the average as compared to 1943, with nearly 60% of the sugars containing 5 p.p.m. or less. The annual figures do not show as wide a variation as for the other components.

Year	Cl p.p.m.
1930	--
1931	16.5
1932	13.0
1933	14.0
1934	5.8
1935	6.6
1936	6.2
1937	11.8
1938	9.5
1939	7.4
1940	7.0
1941	5.0
1942	6.5
1943	7.4
1944	6.5

(5) Lime. (Table 5). There was a very slight decrease in CaO in sugars, perhaps associated with similarly small decreases in lime salts of standard liquors.

The yearly averages have been as follows:

Year	CaO p.p.m.
1930	--
1931	16.5
1932	16.0
1933	12.3
1934	8.4
1935	8.5
1936	8.5
1937	8.4
1938	7.8
1939	10.4
1940	3.5
1941	5.0
1942	4.7
1943	4.9
1944	4.5

(6) Mineral vs. Organic Salts. (Table 5). These salt values are strictly calculated values, but are based on the actual determinations of Cl, SO_2, and SO_3 and specific conductance. In the case of organic salts, a combining weight of 79 is assumed for the organic acid radical. Previously, the salt estimates have been on the basis of the potassium salts. This year, a combined potassium and sodium factor was used, in which the potassium-to-sodium ratio was taken to be 2 to 1 on the ionic basis. This is essentially the general relationship found in previous years. In the individual sugars, the ratio may be very different from this; if the proportion of potassium is greater, then the salt weights shown are a little low; and when sodium exceeds this average condition, then the salt values given are slightly high.

The general tendency for Steffen sugars to contain greater proportions of organic salts than non-Steffen sugars was again observed. The shifting of eleven normally Steffen factories to non-Steffen operation gives a more direct proof of this trend. Some comparative data on sugars from these eleven factories follow:

Comparison of Steffen and Non-Steffen Sugars
from Same Eleven Factories

	*Steffen Sugars Avg. 1940-43 incl.	Non-Steffen Sugars 1944
Specific Conductivity X 10^6	26.8	27.0
Sulphated Ash (soluble)	137 p.p.m.	132 p.p.m.
K_2O-Na_2O Equivalent		
(1) Mineral anions	21 p.p.m.	34 p.p.m.
(2) Organic anions	49 "	33 "
(3) Total anions	70 "	67 "
(4) Organic % Total	70%	49%
Mineral Salts (K-Na, 2 to 1)	44 p.p.m.	62 p.p.m.
Organic Salts "	132 "	90 "
Total Salts "	176 "	152 "

*A very few non-Steffen sugars are included in these averages due to some non-Steffen operation previous to 1944.

It is seen that, while the total bases are nearly the same, the proportion of organically combined bases is much greater when the factories operated the Steffen process. This would presumably be due to recirculation of certain organic acid compounds through precipitation with the sucrate. These organic salts are then taken up by the sugar crystal in preference to more soluble mineral salts. The lower ash in the case of the non-Steffen sugars, in spite of a very slightly higher conductance, is due to the higher specific conductivity of mineral acid ions as compared with organic acid ions. Examples of this are also evident in the data for the individual sugars (Table 5). The comparison of Nos. 4440 and 4495 is an extreme case. With the same specific conductivity, the sulphated ash differs by 11 p.p.m. due to the contrasting salt composition. Due to the higher molecular weight of organic salts, as compared with mineral salts, the contrast in total salt content is greater than in the case of ash values.

The averages for mineral salts increased slightly over last year, while organic salts decreased on the non-Steffen sugars and slightly increased on the Steffen sugars. The changes were small, and in general the 1944 sugars were similar to those for 1943.

(7) Reflectance. (Table 6). Reflectance values showed an average increase over 1943. All the regular sugars had a reflectance above 91. The improvement in annual average reflectance values is evident from the following tabulation:

Year	Reflectance
1934	90.3
1935	90.4
1936	91.0
1937	92.3
1938	91.7
1939	91.5
1940	92.9
1941	91.8
1942	92.0
1943	92.5
1944	93.0

(8) Color and Turbidity in Solution. (Table 6). Both color and turbidity increased slightly for the non-Steffen sugars and both decreased slightly on Steffen sugars; thus the general average was essentially unchanged. While the instruments used and the unit systems were changed some five years ago, the annual values in respect to color and turbidity are shown in the following summary:

Year	Color B-K Units	Turbidity (- log t) Units	Year	Color B-K Units	Color (- log t) Units	Turbidity (- log t) Units
1929	--	60.	1938	7.5	--	6.6
1930	--	31.9	1939	7.2	--	8.3
1931	--	22.5	1940	10.4	--	8.8
1932	--	18.6	1941	9.0	1.62	6.3
1933	--	19.4	1942	--	2.25	4.7
1934	--	19.5	1943	--	2.16	3.5
1935	10.3	14.8	1944	--	2.07	3.5
1936	9.4	11.6				
1937	8.2	11.3				

TABLE 5

MINERAL COMPONENTS, NON-STEFFEN SUGARS

Sample Number	Spec. Cond. X 10^6	Mineral Constituents				*Calculated Ash Values		**Calculated Salt Values		
		SO_2	SO_3	Cl	CaO	Carbonate	Sulphated	Mineral	Organic	Total
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
4401	17.4	2	4	4	3	69	87	21	88	109
4403	28.2	8	20	8	4	107	135	77	76	153
4404	41.5	6	12	27	2	160	202	93	135	228
4405	35.5	5	22	5	3	141	177	67	149	216
4406	23.2	4	9	5	4	91	115	39	103	142
4408	25.0	6	9	12	5	96	121	57	81	138
4410	18.7	4	9	7	1	73	92	42	64	106
4411	32.2	6	21	16	2	121	153	90	80	170
4413	43.0	5	13	3	5	173	219	44	239	283
4414	26.7	3	10	11	1	105	134	47	110	157
4415	20.8	13	10	5	11	79	99	60	46	106
4416	30.7	3	12	4	2	123	155	39	154	193
4417	14.5	4	7	5	5	56	71	34	48	82
4418	25.1	3	10	2	3	100	126	31	128	159
4421	16.5	11	11	4	4	61	77	56	24	80
4422	25.1	8	19	5	4	95	120	68	68	136
4423	18.0	2	10	1	7	71	90	26	85	111
4425	22.5	11	19	10	10	82	103	84	18	102
4427	21.5	5	13	2	1	85	107	42	87	129
4429	23.2	5	12	9	7	89	112	54	74	128
4432	23.8	7	13	9	1	92	116	61	70	131
4433	22.5	7	14	2	10	87	108	49	79	128
4435	25.9	11	17	3	1	100	126	66	78	144
4437	24.2	6	15	2	1	94	119	49	94	143
4439	20.3	14	13	8	1	74	93	76	18	94
4440	30.9	28	21	14	2	116	146	135	0	135
4443	29.7	8	21	3	3	116	146	68	104	172
4447	31.3	2	11	1	1	128	161	29	187	216
4449	23.7	24	15	4	1	86	108	94	10	104
4450	18.6	5	11	3	2	72	91	40	68	108
4452	44.8	28	25	9	29	168	212	133	95	228
4453	17.5	12	10	3	3	66	83	55	34	89
4454	28.0	19	9	10	6	106	133	83	58	141
4455	25.9	7	17	2	4	101	127	55	96	151
4459	36.0	37	18	3	4	132	167	128	40	168
4461	23.9	26	14	9	1	91	115	107	0	107
4463	31.8	5	8	14	3	125	157	56	132	188
4464	15.8	3	7	4	1	61	77	36	53	89
4466	16.2	5	7	0	2	65	82	25	76	101
4469	54.7	9	19	3	3	136	172	65	142	207
4473	25.5	12	1	5	7	100	126	41	112	153
4476	12.6	3	4	1	4	51	65	17	65	82
4479	27.3	17	16	14	7	100	126	101	24	125
4480	50.8	5	16	11	7	118	149	66	108	174
4482	23.3	7	10	4	4	87	110	44	86	130
4484	28.2	4	12	4	5	105	133	42	122	164
4496	35.9	4	11	0	6	147	186	32	211	243
Avg. 1943	25.1	7.2	10.6	6.9	4.8	100	127	54	95	149
Avg. 1944	25.6	9.4	13.0	6.3	4.3	99	125	61	82	143

See notes on next page

TABLE 5

MINERAL COMPONENTS, STEFFEN SUGARS

Sample Number	Spec. Cond. X 10^6	Mineral Constituents				*Calculated Ash Values		**Calculated Salt Values		
		SO_2 ppm	SO_3 ppm	Cl ppm	CaO ppm	Carbonate ppm	Sulphated ppm	Mineral ppm	Organic ppm	Total ppm
4407	25.2	7	9	4	1	100	126	42	111	153
4420	23.8	8	8	7	5	94	118	49	89	138
4426	23.2	3	17	6	7	90	113	54	78	132
4428	18.2	3	11	11	6	69	87	51	43	94
4430	38.2	7	22	10	6	147	186	82	139	221
4431	26.5	8	14	3	3	104	131	54	104	158
4441	22.9	7	12	4	1	89	112	48	83	131
4442	23.0	7	10	2	2	90	114	41	99	140
4446	21.8	9	21	1	1	82	104	66	50	116
4456A	25.7	7	14	11	3	98	124	67	73	140
4456B	24.0	6	13	9	1	92	116	59	73	132
4457	19.4	5	20	2	5	74	93	57	48	105
4460	32.8	15	37	9	7	120	151	128	23	151
4465	26.0	5	11	2	2	105	132	38	128	166
4471	15.8	2	7	1	4	63	79	21	79	100
4472	30.8	11	3	14	3	120	151	61	116	177
4475	50.1	5	43	13	24	193	243	125	153	278
4477	38.5	6	8	16	4	151	191	62	168	230
4478	22.8	3	8	13	3	87	110	49	77	126
4483	16.6	2	5	5	8	66	83	25	77	102
4484	21.1	12	11	4	5	81	102	59	55	114
4495	30.8	7	9	4	13	123	157	43	153	196
Avg.1943	25.4	6.8	11.1	8.1	4.9	101	126	57	86	143
Avg.1944	26.1	6.6	14.5	6.9	5.0	101	127	59	90	149

* Estimated on basis of specific conductance and composition

** Salt values calculated as mixed potassium and sodium salts in ionic ratio of 2 to 1. This was previously found to be the average relationship of these two elements.

Note: Ash values are for soluble ash or silica-free ash. The 1943 values are the gravimetric results decreased by the determined silica or acid insolubles. The 1944 values are based on specific conductivity.

TABLE 6

PHYSICAL PROPERTIES AND RATING
NON-STEFFEN SUGARS

Sample Number	Reflectance Sugar	Sugar Solution			Foaming Test		Formula Rating
		Color	Turbidity	pH	Maximum	Final	Percentage
4401	91.6	2.1	3.6	7.50	90	80	95.8
4403	92.0	2.6	3.0	7.61	100	80	93.4
4404	93.3	1.4	1.9	7.42	105	85	95.9
4405	93.2	1.9	2.1	7.55	105	80	95.7
4406	94.3	1.5	2.4	7.59	100	90	98.8
4408	91.5	1.6	2.4	7.38	115	90	93.0
4410	91.7	1.5	2.1	7.50	100	80	96.0
4411	91.9	0.7	1.5	7.38	100	85	96.5
4413	91.4	1.5	2.1	7.31	110	90	92.8
4414	94.0	2.0	1.9	7.98	115	85	96.3
4415	93.8	2.1	3.0	7.30	105	80	95.5
4416	93.2	1.5	2.2	7.55	105	85	96.7
4417	93.1	0.9	4.9	7.82	85	75	98.6
4418	92.3	4.5	3.7	7.55	110	80	90.5
4421	92.7	3.4	3.7	7.00	105	85	92.5
4422	93.0	1.2	2.8	7.13	100	80	96.8
4423	93.5	0.9	1.3	7.32	100	80	99.7
4425	93.6	1.0	1.5	7.12	100	90	98.3
4427	91.7	3.5	6.8	7.36	100	75	90.2
4429	94.2	1.6	3.6	7.56	90	80	98.9
4432	94.4	2.4	2.3	7.30	100	80	97.4
4433	92.3	1.8	3.0	7.03	105	90	94.4
4435	92.2	1.9	2.4	7.11	110	90	93.6
4437	95.1	2.4	2.8	7.35	100	85	98.0
4439	93.6	2.4	4.0	6.90	100	75	94.7
4440	93.4	1.1	5.9	7.08	100	75	93.1
4443	93.0	1.6	2.1	7.20	100	85	96.5
4447	93.0	2.3	3.6	8.01	105	90	94.6
4449	92.6	1.2	5.3	7.00	100	75	92.8
4450	93.3	0.9	3.4	7.32	100	80	97.9
4452	91.8	3.2	19.4	7.41	95	85	79.0
4453	92.5	1.2	4.0	6.72	100	75	95.3
4454	93.7	0.8	8.3	6.80	100	85	93.1
4455	93.5	1.8	2.4	6.92	110	90	95.5
4459	94.3	1.1	1.6	6.55	115	90	93.0
4461	93.7	1.9	7.4	6.68	100	80	91.8
4463	92.5	1.9	3.7	7.15	115	85	92.8
4464	92.6	2.2	3.6	7.01	120	95	92.7
4466	94.2	1.4	3.0	7.02	110	85	97.3
4469	92.5	1.8	3.6	7.31	125	85	91.1
4473	94.5	1.3	5.7	7.00	105	85	95.5
4476	93.2	3.0	2.7	7.40	100	80	96.3
4479	94.0	2.7	5.7	6.80	100	80	93.0
4480	94.0	4.2	2.8	7.35	105	85	93.7
4482	93.4	2.8	1.5	7.30	115	80	94.6
4494	92.5	3.6	6.4	7.51	95	85	92.0
4496	87.4	2.2	7.6	7.11	110	90	84.1
Avg. 1943	92.4	1.89	3.09	7.11	121	89	92.5
Avg. 1944	93.1	1.93	3.70	7.26	104	83	94.7

TABLE 6

PHYSICAL PROPERTIES AND RATING
STEFFEN SUGARS

Sample Number	Reflectance of Sugar	Sugar Solution			Foaming Test		Formula Rating Percentage
		Color	Turbidity	pH	Maximum	Final	
4407	93.2	1.9	2.7	7.60	105	85	95.7
4420	92.5	1.5	2.3	7.60	95	90	96.8
4426	94.3	2.8	2.7	7.32	105	85	96.5
4428	91.1	4.5	5.4	7.36	100	80	89.8
4430	91.5	2.1	2.4	7.70	95	85	94.1
4431	93.7	0.9	3.0	7.45	105	95	97.0
4441	92.6	2.8	1.4	7.09	105	90	94.7
4442	93.9	2.8	2.4	7.19	105	85	95.7
4446	93.6	2.1	3.7	6.93	100	85	95.8
4456A	93.3	1.2	1.5	7.25	105	85	97.4
4456B	93.1	0.7	1.3	7.21	110	75	97.5
4457	93.7	2.1	3.0	6.98	105	85	96.3
4460	94.5	1.6	2.1	6.58	110	85	95.9
4465	92.1	1.1	2.4	7.10	105	80	95.5
4471	91.7	4.7	4.6	7.38	105	90	90.2
4472	92.6	1.2	0.8	7.28	105	95	96.0
4475	94.2	1.5	6.7	7.08	115	100	92.5
4477	92.5	5.7	3.9	7.20	105	85	88.8
4478	93.1	3.6	4.6	7.55	100	80	93.4
4483	91.7	2.1	2.4	7.10	105	85	94.8
4484	94.5	1.3	2.9	7.00	105	90	97.4
4495	92.7	5.8	3.0	7.11	120	100	87.7
Avg. 1943	92.7	2.43	3.81	7.10	136	92	89.9
Avg. 1944	93.0	2.36	3.04	7.24	104	87	94.7

Note 1. Color and turbidity expressed as $(-\log t)10^3$

(9) Foaming Test. (Table 6). Further supplementary studies to account for the high foaming values of last year were unsuccessful. This season's results are generally low, and again no amount of retesting and special tests can significantly alter them. Moderate stirring was used up to 90°C, as has been done for several years. It is to be noted that the final foaming readings are also low. A summary of annual values follows:

Year	Maximum	Final	Year	Maximum		Final
1929	125	68	1937	98		83
1930	90	65	1938	101		82
1931	96	65	1939	99	New*	
1932	90	72	1940	95		83
1933	88	72	1941	96	115	84
1934	84	73	1942	--	103	81
1935	83	72	1943	--	128	90
1936	92	71	1944	--	104	85

*Tests made with stirring

Considering just the final foaming, there seems to have been a trend toward higher foaming tests in the past ten years.

(10) Formula Ratings. (Table 6). Due largely to the higher reflectances and lower foaming tests, the general level of the formula ratings is higher than it has been to date. As for last year, the percentage ratings given are based on a standard sugar with a normal formula rating of 81. Due to the exceptional fluctuation in the foaming tests for the past few years, it appears possible that this determination has too much weight in the rating. Since all samples appear to be equally affected by this seasonal variation in foaming, it is evident that the comparisons between individual factories are not unduly influenced, even though annual averages are.

(11) Screening Tests. (Table 7). The screening shows a trend back to a finer-grained sugar, although retention on the No. 40 screen was still not as low as in 1941-2.

TABLE 7

SCREENING TESTS, NON-STEFFEN SUGARS

Sample Number	Percent Retained on Screens U.S. No.								Thru 100	Summary			
	20	30	40	50	60	70	80	100		on #30	30-50	50-70	Thru #70
4401	0.0	7.6	43.2	31.2	8.0	4.4	2.8	1.8	1.0	7.6	74.4	12.4	5.6
4403	0.2	1.0	31.6	44.4	9.4	5.2	3.8	2.6	1.8	1.2	76.0	14.6	8.2
4404	0.0	3.0	28.8	36.6	10.6	7.6	6.0	4.2	3.2	3.0	65.4	18.2	13.4
4405	0.0	0.4	27.0	42.8	9.6	8.8	5.6	4.2	1.6	0.4	69.8	18.4	11.4
4406	0.0	1.0	28.8	42.4	9.2	8.0	5.0	3.8	1.8	1.0	71.2	17.2	10.6
4408	0.8	1.6	24.6	39.2	10.2	7.8	6.8	5.2	3.8	2.4	63.8	18.0	15.8
4410	0.0	1.2	29.8	38.4	10.4	7.6	5.6	4.4	2.6	1.2	68.2	18.0	12.6
4411	0.2	5.6	46.8	28.0	6.8	4.4	3.6	2.8	1.8	5.8	74.8	11.2	8.2
4413	0.2	3.6	41.0	33.6	8.6	6.0	3.8	2.2	1.0	3.8	74.6	14.6	7.0
4414	0.0	0.2	19.2	50.6	7.8	8.6	5.6	5.0	3.0	0.2	69.8	16.4	13.6
4415	0.0	1.0	19.8	42.8	9.8	9.2	7.2	5.8	4.4	1.0	62.6	19.0	17.4
4416	0.0	1.0	34.8	41.6	7.6	6.4	4.4	2.8	1.4	1.0	76.4	14.0	8.6
4417	0.0	0.2	22.2	50.0	9.4	7.6	5.0	4.0	1.6	0.2	72.2	17.0	10.6
4418	0.2	1.8	32.8	37.0	8.6	7.6	5.4	4.4	2.2	2.0	69.8	16.2	12.0
4421	0.0	0.2	21.6	54.2	9.4	6.0	3.8	2.6	2.2	0.2	75.8	15.4	8.6
4422	0.0	0.6	19.4	45.2	9.8	8.6	6.6	5.8	4.0	0.6	64.6	18.4	16.4
4423	0.2	0.6	19.4	44.4	11.2	7.8	6.6	5.8	4.0	0.8	63.8	19.0	16.4
4425	0.0	0.2	22.2	46.6	8.6	7.4	6.0	5.4	3.6	0.2	68.8	16.0	15.0
4427	0.0	1.2	29.2	40.0	8.6	7.4	5.4	4.6	3.6	1.2	69.2	16.0	13.6
4429	0.0	0.4	16.2	42.6	9.0	9.8	7.8	7.2	7.0	0.4	58.8	18.8	22.0
4432	0.0	0.4	17.8	46.2	10.6	8.8	6.6	5.4	4.2	0.4	64.0	19.4	16.2
4433	0.2	6.2	44.2	29.2	8.4	4.2	3.4	2.6	1.6	6.4	73.4	12.6	7.6
4435	0.0	0.2	10.6	51.6	10.6	10.2	7.0	6.2	3.6	0.2	62.2	20.8	16.8
4437	0.0	0.4	27.6	42.8	8.8	6.8	5.8	5.0	2.8	0.4	70.4	15.6	13.6
4439	0.2	3.2	45.4	38.6	7.0	3.2	1.6	0.6	0.2	3.4	84.0	10.2	2.4
4440	0.0	0.2	35.8	44.8	6.8	5.2	3.6	2.4	1.2	0.2	80.6	12.0	7.2
4443	0.2	1.0	25.8	44.8	9.6	7.2	5.2	3.6	2.6	1.2	70.6	16.8	11.4
4447	0.0	3.8	47.4	30.8	6.6	4.4	3.4	2.4	1.2	3.8	78.2	11.0	7.0
4449	0.0	0.6	29.2	40.6	8.3	7.2	5.4	5.0	3.8	0.6	69.8	15.4	14.2
4450	0.0	0.8	39.8	42.0	7.6	4.4	2.8	1.9	0.8	0.8	81.8	12.0	5.4
4452	0.2	9.0	36.8	29.4	8.2	5.4	4.2	3.4	3.4	9.2	66.2	13.6	11.0
4453	0.2	0.2	17.8	51.4	9.6	7.2	5.8	4.6	3.2	0.4	69.2	16.8	13.6
4454	0.0	0.2	18.4	49.8	9.4	7.6	6.0	5.2	3.4	0.2	68.2	17.0	14.6
4455	0.2	2.4	28.6	40.6	8.8	7.0	5.0	4.2	3.2	2.6	69.2	15.8	12.4
4459	0.0	3.8	34.8	34.2	9.4	6.8	5.2	3.8	2.0	3.8	69.0	16.2	11.0
4461	0.0	0.2	14.8	52.4	13.6	7.6	5.6	3.6	2.2	0.2	67.2	21.2	11.4
4463	0.2	7.0	32.6	36.2	9.6	6.4	4.2	2.6	1.2	7.2	68.8	16.0	8.0
4464	0.4	0.4	23.4	47.8	11.0	7.2	4.8	3.2	1.8	0.8	71.2	18.2	9.8
4466	0.0	0.8	25.4	41.8	8.4	7.2	6.2	5.6	4.6	0.8	67.2	15.6	16.4
4469	0.0	0.4	33.8	41.6	7.6	6.0	4.4	3.6	2.6	0.4	75.4	13.6	10.6
4473	0.2	4.6	31.4	33.8	8.8	7.0	6.0	4.8	3.4	4.8	65.2	15.8	14.2
4476	0.0	0.4	19.6	49.0	11.4	7.6	5.2	4.0	2.8	0.4	68.6	19.0	12.0
4479	0.0	0.2	15.2	52.8	11.2	7.8	5.8	4.2	2.8	0.2	68.0	19.0	12.8
4480	0.0	1.6	21.8	35.6	10.0	10.0	8.6	7.8	4.6	1.6	57.4	20.0	21.0
4482	0.0	0.2	13.6	48.0	13.6	9.4	7.4	4.8	3.0	0.2	61.6	23.0	15.2
4494	0.2	3.8	33.6	39.0	8.6	6.0	4.2	3.0	1.6	4.0	72.6	14.6	8.8
496	0.8	13.2	39.8	29.8	8.0	4.2	2.6	1.2	0.4	14.0	69.6	12.2	4.2
Avg.1943	0.0	2.0	32.4	39.5	8.2	6.7	5.0	3.9	2.2	2.0	71.9	14.9	11.2
Avg.1944	0.0	1.9	27.8	41.9	9.3	7.1	5.2	4.1	2.7	1.9	69.7	16.4	12.0

TABLE 7

SCREENING TESTS, STEFFEN SUGARS

Sample	Percent Retained on Screens U.S. No.								Thru	Summary			
Number	20	30	40	50	60	70	80	100	100	on #30	30-50	50-70	Thru #70
4407	0.0	0.4	23.8	50.4	9.6	6.2	4.8	3.0	1.8	0.4	74.2	15.8	9.6
4420	0.0	0.2	14.8	48.6	11.4	8.4	6.4	5.6	4.6	0.2	63.4	19.8	16.6
4426	0.0	2.0	35.4	36.6	9.0	6.2	5.2	3.8	1.8	2.0	72.0	15.2	10.8
4430	0.2	2.6	32.8	35.4	8.6	7.0	6.0	4.8	2.6	2.8	68.2	15.6	13.4
4431	0.0	0.4	24.0	44.6	10.6	6.4	6.0	4.8	3.2	0.4	68.6	17.0	14.0
4441	0.0	0.6	33.8	45.6	8.2	4.4	3.6	2.4	1.4	0.6	79.4	12.6	7.4
4442	0.0	1.2	21.8	39.6	10.2	8.0	7.2	6.6	5.4	1.2	61.4	18.2	19.2
4446	0.0	1.4	34.8	41.4	7.4	6.0	4.4	3.0	1.6	1.4	76.2	13.4	9.0
4456A	0.0	1.2	34.2	43.2	9.0	4.8	3.8	2.4	1.4	1.2	77.4	13.8	7.6
4456B	0.0	0.8	35.0	45.4	8.2	4.2	3.0	2.0	1.4	0.8	80.4	12.4	6.4
4457	0.0	0.2	21.8	51.4	8.8	6.8	5.0	3.8	2.2	0.2	73.2	15.6	11.0
4460	0.0	1.0	22.8	40.6	10.8	8.4	7.2	5.6	3.6	1.0	63.4	19.2	16.4
4465	0.2	2.0	41.6	36.4	7.8	4.6	3.2	2.4	1.8	2.2	78.0	12.4	7.4
4471	0.0	2.2	35.2	37.4	9.2	6.0	4.6	3.4	2.0	2.2	72.6	15.2	10.0
4472	0.2	0.4	27.8	48.8	9.4	5.2	3.8	2.8	1.6	0.6	76.6	14.6	8.2
4475	0.0	0.2	14.6	38.8	11.4	10.4	9.2	9.0	6.4	0.2	53.4	21.8	24.6
4477	0.0	0.4	35.0	44.8	8.0	4.8	3.6	2.2	1.2	0.4	79.8	12.8	7.0
4478	0.0	1.0	29.4	47.0	9.2	5.8	4.0	2.6	1.0	1.0	76.4	15.0	7.6
4483	0.2	1.0	46.2	36.4	6.4	4.4	2.8	2.0	0.6	1.2	82.6	10.8	5.4
4484	0.0	0.2	12.6	52.2	10.6	8.2	6.2	5.2	4.8	0.2	64.8	18.8	16.2
4495	0.2	2.8	34.2	34.4	9.2	6.2	5.4	4.4	3.2	3.0	68.6	15.4	13.0
Avg.1943	0.0	0.8	30.5	41.6	8.3	6.7	5.2	4.3	2.6	0.8	72.1	15.0	12.1
Avg.1944	0.0	1.0	28.9	43.2	9.2	6.3	5.0	3.9	2.5	1.0	72.1	15.5	11.4

C. Specific Conductivity in Relation to Salt Composition

It is well known that a uniform conductivity-ash factor or C-ratio often yields "ash" values quite different from those obtained by the gravimetric determination of ash. Besides the difficulties in accurate determination of the gravimetric ash on low-ash products such as refined sugars, there are two conditions inherent in the conductivity determination itself which add to the fluctuation of the C-ratio and therefore increase the error in the use of a uniform factor. One of these conditions is the presence of silica or insolubles which does not affect conductivity but contributes to the gravimetric ash. The other general factor is the large difference in the composition and ionization of the soluble salts that produce the conductivity. Potassium salts yield higher conductance than sodium or calcium salts; chloride ions have an especially high conductivity in relation to their weight, while sulphate and sulphite ions are lower in conductivity. The mineral anions just mentioned have a greater conductivity than most organic acid ions. In beet sugar it is probable that the organic anions have conductivities as low or lower than that of the acetate ion. Because of the contrast between the conductivities of the mineral salts and of the organic salts, it is conceivable that the ratio of determined mineral salts to determined conductivity could be correlated with the proportion of these mineral salts. If a particular specific conductance in one instance were due primarily to mineral salts, then the ratio of the sum of the mineral salts (on an equivalent basis) to the conductivity would be high. If this same specific conductivity were derived from a small quantity of mineral salts and a larger equivalent

weight of organic salts, then the ratio of the mineral components to conductivity would be low. Since true ash alkalinity, in addition to the chloride, sulphate and sulphite ions has been determined for several years, it is possible to develop this correlation.

All elements must be handled on an equivalent-weight basis. Therefore, the determined chloride, sulphate and sulphite ions were first calculated to the basic equivalents, the mixed potassium and sodium oxides in the ratio of 2 to 1 being used as the combining weight of the base. Corresponding basic equivalents were calculated for the ash alkalinities. The sum of all of these represents the total basic equivalent for the anions present. The ratio of the sum of the mineral basic equivalents to the total is the percent of bases combined with mineral acids. The sum of the mineral basic equivalents divided by the measured conductivity yielded factors or special C-ratios which were easily correlated with these percentages of mineral basic equivalents to total basic equivalents. The special C-ratios were not perfectly uniform for identical proportions of mineral to total basic equivalents, since the relation between quantities of chloride, sulphate and sulphite was still a variable. However, the degree of uniformity was excellent.

The next procedure was to determine the equivalent specific conductivities of known potassium and sodium salts in the presence of 30 grams of sugar. Potassium and sodium chlorides, sulphates and sulphites were used to represent the inorganic salts, and potassium and sodium acetates, to represent the organic salts. The values for the mixed salts of potassium and sodium in the 2 to 1 ratio were estimated by calculation. From

TABLE 8

Correlation of the Special C_{ma-eq}-ratio and Regular C-ratio with Proportion of Mineral Basic Equivalents

*Mineral Anions % Total		**C_{ma-eq}-ratio	***C-ratio
100	--------	0.000231	0.000452
95	--------	221	455
90	--------	211	459
85	--------	200	463
80	--------	190	466
75	--------	179	470
70	--------	169	473
65	--------	158	477
60	--------	147	481
55	--------	136	484
50	--------	124	488
45	--------	112	492
40	--------	101	496
35	--------	089	500
30	--------	077	504
25	--------	065	508
20	--------	052	512
15	--------	040	516
10	--------	027	521
5	--------	014	525
0	--------	000	530

*Sum of K_2O-Na_2O(2 to 1) equivalents of mineral anions (Cl, SO_2, SO_3) X 100 divided by total basic equivalents. The mineral anions are assumed to be in the proportions of 38 parts SO_2, 35 parts SO_3, and 27 parts Cl (ionic basis), as found in the four-year averages.

**The special ratio of mineral anion basic equivalents to specific conductivity.

***The regular ratio of sulphated ash (soluble) to specific conductivity.

these conductivities of known salts, the theoretical conductivities were calculated for mixtures ranging from the condition when all 100 parts of basic equivalents were present in combination with mineral anions of average composition to the condition when the 100 parts of basic equivalents were in combination with organic anions. Further calculation yielded the regular C-ratios, which were also correlated with the percentages of mineral anion equivalents and with the special C_{ma-eq}-ratios. These comparative figures are given in Table 8.

The use of Table 8, which requires a knowledge of the Cl, SO_2 and SO_3 contents and specific conductivity of the sugar, makes possible an approximation of the ash alkalinity as well as ash values. When these calculations were applied to individual sugars of recent years, it was found that, with extremely few exceptions, the estimated equivalent of ash alkalinity agreed closely with the determined figures.

The ash alkalinity, in terms of its organic anion basic equivalent can be calculated to organic salts by assuming an arbitrary combining weight for the organic acid. The use of the C_{ma-eq}-ratio is much limited by the necessity for the extensive analytical data, which are not commonly determined. However, it provides a means for estimating ash values and salt values more accurately in connection with our work on the annual samples of sugar. This discussion is presented primarily because the method was used in arriving at the figures given in Table 5. Taking, for example, a sugar having specific conductance of 25.0 and mineral anion composition of SO_2-6p.p.m., SO_3-8 p.p.m., and Cl-4 p.p.m., the calculation procedure is as follows:

SO_2 -- 6 X 1.30 = 7.8 p.p.m. K_2O-Na_2O(2 to 1) equivalent
SO_3 -- 8 X 1.04 = 8.3 " " "
Cl -- 4 X 1.17 = 4.7 " " "
Sum 20.8 " " " or 0.00208% on sugar
0.00208/ 25.0 = 0.000083 special ratio (C_{ma-eq})
According to Table 8, this ratio indicates a mineral percentage of 32.5
(20.8/32.5) X 100 = 64.0 p.p.m. total basic equivalent
64.0-20.8 = 43.2 p.p.m. basic equivalent for organic anions
43.2 X 2.70 = 116.6 p.p.m. organic salt (basis of 79 combining weight of organic anion)
6 X 2.30 = 13.8 p.p.m. sulphites (mixed bases as above)
8 X 2.04 = 16.3 " sulphates " " " "
4 X 1.95 = 7.8 " chlorides " " " "
Sum 154.5 p.p.m. total salts
64.0 X 1.96 = 125.4 p.p.m. sulphated ash or
regular C factor corresponding to 32.5% minerals is 0.000502
then 0.000502 X 25.0 X 10000 = 125.5 p.p.m. sulphated ash
125.5 X 0.78 = 97.8 p.p.m. carbonated ash
5.5 p.p.m. silica added to ash values approximates gravimetric ash
i.e. sulphated ash is 131 p.p.m. or 0.0131% on sugar
carbonated ash 103 p.p.m. or 0.0103% " "
total salts is 160 p.p.m. or 0.0160% " "

The values tabulated in Table 5 are for soluble constituents, and no silica correction has been applied. The sulphated ash was estimated from the total basic equivalent calculated as above. The mineral salt totals were calculated from the actual analyses for constituents on the basis of the mixed potassium and sodium salts, and the organic salts were estimated from the calculated organic anion basic equivalent. As previously, the combining weight of the organic anion was assumed to be 79.

To examine the effects of the use of this type of calculation, it was applied to the 319 sugars analyzed from 1940 to 1943 inclusive and compared with the gravimetric results for ashes on these sugars. In 41% of these examples, the calculated soluble ash agreed with the gravimetric results for soluble ash to within ±5 p.p.m., and in 67% of them to within ±10 p.p.m. The more extreme variations were studied further, but there

was no peculiarity in the compositions that explained the erratic gravimetric results for ash; it is felt that the calculated values are probably nearer the absolute amounts of ash than the gravimetric values actually determined. This conclusion is partly based on the known difficulty of obtaining reliable gravimetric ash figures on refined sugars.

In a review of the variation in results of gravimetric ash determination on 86 sugars, it was found that the deviation between duplicate tests by an individual operator in extreme cases amounted to 20 p.p.m. and averaged ±5 p.p.m. The difference between the averages of duplicate determinations by two operators averaged ±12 p.p.m. and in individual instances was as much as 40 p.p.m. These variations occurred in spite of using controlled-temperature electric muffles, platinum dishes, 50 grams of sugar per test, and care in all manipulations. As specific conductivity, on the other hand, is almost exactly duplicated by different operators, it is concluded that when gravimetric ash differs greatly from the calculated ash adjusted for mineral anion composition the gravimetric ash is more likely to be in error. Small differences between gravimetric and calculated ash are normal because of variation in the composition of the salts.

When the analyses on the four (or less) sugars from each factory were averaged to obtain a factory average for four years, the calculated ashes agreed with the determined ashes closely. Some 68% differed by only ±5 p.p.m., and 96% agreed within ±10 p.p.m. Further, when the factory averages were grouped by areas and averaged, the differences between determined and calculated ashes became small indeed. In Table 9 data are given for the factory averages grouped by areas. Also, this table shows the sulphated-ash C-ratio ($X\ 10^6$) for each factory that has resulted from this comprehensive

examination of our data. In preparing similar reports in the future, the ash values will be estimated as they were this year from the specific conductivity and composition with respect to SO_2, SO_3, and Cl for each particular sugar. However, in factory or central laboratory examination of sugars where figures for these three mineral constituents are lacking, it is believed that the C-ratios here presented could be used to advantage, provided the 30-grams per-100 cc. concentration of sugar be adopted. It is certain that large numbers of samples have been studied to establish these ratios, and they are adjusted to the general composition of the sugars of the individual factory. A normal silica content of 5 p.p.m. may be added to the soluble-ash value, obtained by use of the C-ratio and specific conductivity, to estimate total ash.

Another observation which resulted from these studies was that the carbonated ashes (soluble) and sulphated ashes (soluble) were in almost the exact relationship indicated by theoretical calculation. That is, the carbonated ash is essentially potassium, sodium, and calcium carbonate and practically free from sulphate or other mineral anions (as independently found to be the case by analysis of ashes). The carbonated ash (soluble), on the basis of the mixed bases K_2O-Na_2O(2 to 1), is theoretically 78% of the sulphated ash; the actual determined relationship on the 319 sugars analyzed was 78.2%. It is certain that the 10% deduction frequently made from sulphated ash to approximate carbonated ash is greatly misleading, since the deduction should be 22% on the soluble-ash basis. For total ash including a normal amount of silica, the deduction would be 21%.

D. Comparative C-ratios for Sugars, White Massecuites, and Molasses

In the preceding report (on 1943 sugars, page 39), the data presented on this subject contained a general error with regard to position of the decimal point on specific conductivity (X 10^6) and the C-ratios for massecuite and molasses. The specific conductivity for the massecuite should read 3978, and that for molasses, 13140; these changes would make the carbonated ash factor for white massecuite 0.000573 and that for molasses, 0.001101. The factors for sulphated ash and salts should be similarly changed. All of the C-ratios in this 1943 report are based on total ash.

E. Summary

The analytical data obtained on the 1944 sugars indicate a general maintenance of quality and further improvement in reflectance values. The ash figures were estimated on the basis of the specific conductivity and the individual composition with respect to SO_2, SO_3, and Cl. The method of using these determinations for the calculation of ash alkalinity, as well as ash values, has been presented. The C-ratios for the sugars of individual factories are seen to vary quite widely; it is suggested that these adjusted factors be used to improve ash estimations based on specific conductivity.

TABLE 9

COMPARATIVE GRAVIMETRIC AND CALCULATED ASH VALUES

Factory Number	Silica ppm	Carbonated Ash (soluble)		Sulphated Ash (soluble)		Ash Alkalinity Basic Equiv.		Mineral Anions Basic Equiv.		C-ratio Sulp. Ash
		Det'd. ppm	Calc'd. ppm	Det'd. ppm	Calc'd. ppm	Det'd. ppm	Calc'd. ppm	Det'd. ppm	% Total b.e.	X 10^6
East-Steffen										
19	18	126	132	175	169	71	68	19	22	510
58	7	149	145	180	190	70	73	22	23	510
1	2	81	81	100	104	37	40	13	25	508
55	4	102	97	128	124	36	47	16	25	508
27	8	143	135	181	173	72	65	23	26	507
62	6	106	105	133	135	42	46	17	27	507
63	6	107	116	134	149	45	55	21	28	506
4	7	149	154	192	198	66	71	30	30	504
9	5	122	116	152	149	53	53	24	31	503
13	4	105	99	141	127	49	41	23	36	500
Average	--	119	118	152	152	54	56	21	27	507
East-Non-Steffen										
47	2	125	126	153	162	63	69	13	16	515
66	5	79	70	105	89	43	35	11	24	508
38	1	75	76	99	97	38	38	12	24	508
23	4	94	94	121	121	41	43	19	31	503
36	7	117	116	148	148	46	47	28	37	499
18	4	106	100	130	128	35	33	21	39	497
51	9	98	101	130	130	38	34	30	47	491
33	8	92	82	118	105	24	20	25	55	484
52	26	85	88	114	113	23	25	33	57	483
Average	--	97	95	124	121	39	38	21	36	500
Plains-North-Steffen										
68	5	142	147	191	189	68	63	33	34	501
7	7	80	82	99	106	33	34	19	35	500
46	4	72	70	96	90	31	29	16	35	500
77	2	132	124	157	159	44	50	31	38	498
84	6	108	111	140	143	34	36	37	51	488
Average	--	107	107	137	137	42	42	27	39	497
Plains-North-Non-Steffen										
5	7	87	91	109	117	34	38	22	37	499
16	7	88	90	111	115	32	36	23	39	497
35	3	86	93	110	119	30	35	26	43	494
69	8	86	93	113	119	26	33	28	46	492
15	5	76	79	98	101	26	27	24	47	491
43	12	72	85	94	109	26	28	27	49	489
21	7	76	69	103	88	21	17	28	62	480
Average	--	82	86	105	110	28	31	25	45	492

TABLE 9 CONT'D.

COMPARATIVE GRAVIMETRIC AND CALCULATED ASH VALUES

Factory Number	Silica ppm	Carbonated Ash (soluble) Det'd. ppm	Carbonated Ash (soluble) Calc'd. ppm	Sulphated Ash (soluble) Det'd. ppm	Sulphated Ash (soluble) Calc'd. ppm	Ash Alkalinity Basic Equiv. Det'd. ppm	Ash Alkalinity Basic Equiv. Calc'd. ppm	Mineral Anions Basic Equiv. Det'd. ppm	Mineral Anions Basic Equiv. % Total b.e.	C-ratio Sulp. Ash X 10^6
Plains-South-Steffen										
28	9	164	168	209	216	63	67	43	39	497
41	5	99	100	126	128	36	38	27	42	495
65	4	107	102	132	130	40	39	28	42	495
42	6	90	92	120	118	35	35	26	43	494
75	2	120	117	150	150	42	42	35	45	492
48	4	124	124	162	159	45	43	38	47	491
30	3	126	126	155	161	37	42	40	49	489
31	6	109	103	136	132	33	32	35	52	487
26	5	89	92	117	118	29	27	31	53	486
24	10	106	105	134	134	31	28	41	59	482
56	8	78	83	97	106	18	22	32	59	482
60	9	131	132	166	168	28	28	58	67	476
72	5	116	110	146	141	32	27	45	63	479
Average	--	112	112	142	143	36	36	37	51	488
Plains-South-Non-Steffen										
3	2	78	77	94	99	16	19	31	60	481
73	3	109	110	141	141	29	29	43	60	481
22	7	97	98	118	126	25	25	39	61	480
50	3	64	64	83	82	17	16	25	61	480
82	7	80	83	99	106	18	21	34	62	480
11	12	98	101	124	129	24	24	41	63	479
44	9	67	70	83	90	18	17	29	63	479
25	3	90	81	110	104	23	19	34	64	478
10	6	68	72	91	92	14	16	31	66	477
32	2	79	72	95	92	12	13	35	73	471
Average	--	83	83	104	103	19	20	34	63	479
Intermountain-North-Steffen										
79	2	121	109	150	139	43	38	33	47	491
40	2	124	120	167	153	41	37	41	53	486
Average	--	122	115	168	146	42	38	37	49	489
Intermountain-North-Non-Steffen										
12	5	138	130	166	166	34	35	50	59	481
54	3	109	99	134	127	12	11	53	83	485
59	5	109	107	142	137	8	10	60	86	463
61	8	89	86	113	111	5	5	51	91	459
49	3	102	93	127	119	8	5	55	92	458
Average	--	109	103	136	132	13	13	54	81	466

TABLE 9 CONT'D.

COMPARATIVE GRAVIMETRIC AND CALCULATED ASH VALUES

Factory Number	Silica ppm	Carbonated Ash (soluble) Det'd. ppm	Carbonated Ash (soluble) Calc'd. ppm	Sulphated Ash (soluble) Det'd. ppm	Sulphated Ash (soluble) Calc'd. ppm	Ash Alkalinity Basic Equiv. Det'd. ppm	Ash Alkalinity Basic Equiv. Calc'd. ppm	Mineral Anions Basic Equiv. Det'd. ppm	Mineral Anions Basic Equiv. % Total b.e.	C-ratio Sulp. Ash X 10^6
Intermountain-South-Steffen										
37	6	106	113	138	145	51	50	24	32	503
74	2	110	94	126	120	43	43	18	30	504
29	5	87	88	114	113	34	33	24	42	495
20	3	78	85	101	108	27	30	26	47	491
70	7	118	111	151	142	48	36	37	51	488
Average	--	100	98	126	126	41	38	26	41	495
Intermountain-South-Non-Steffen										
8	6	81	82	101	105	35	38	15	28	505
67	4	73	76	91	97	30	35	14	29	505
14	2	91	95	116	122	36	42	20	32	503
39	4	144	135	181	173	58	53	35	40	496
80	6	102	103	130	132	33	36	31	46	491
Average	--	98	98	124	126	38	41	19	32	503
West-Steffen										
2	5	60	63	80	81	33	30	11	27	507
71	9	62	62	79	79	32	28	13	32	503
83	4	64	65	86	84	28	27	15	36	500
57	7	76	77	99	99	30	30	20	40	496
64	4	63	60	84	77	26	21	18	46	492
53	5	75	73	91	93	27	23	24	51	488
Average	--	67	67	86	85	29	26	17	39	496
West-Non-Steffen										
6	4	97	98	125	126	45	45	19	30	504
45	3	59	63	83	81	26	24	17	41	496
34	4	69	69	87	88	29	25	20	44	493
76	2	52	53	62	67	14	18	17	49	489
17	13	52	52	74	67	17	13	22	63	478
Average	--	66	67	86	86	26	25	19	43	494

PART II

BIOLOGICAL STUDIES OF SUGARS

H. H. Hall and Dorothea J. Teunisson

Samples of beet sugar collected during the 1944 campaign were studied as in previous years in order to appraise their biological qualities. They were cultured for quantitative determination of mesophilic bacteria, aerobic and anaerobic thermophiles, and yeasts and molds. The yeast-inoculum multiple was again determined to indicate the relative amount of yeast-growth-promoting substances in each sugar. Further investigation was made on the growth of molds in highly concentrated sugar solutions prepared from sugars of the 1942 and 1943 campaigns.

BACTERIOLOGICAL EXAMINATION

All samples of sugar were examined for the numbers of thermophilic anaerobic and aerobic bacteria that might cause spoilage or affect the flavor of canned foods, and of mesophilic bacteria, yeasts, and molds that might modify desirable characteristics of beverages, dairy products, frozen foods, desserts, and candies.

The same methods were used for the determination of thermophilic organisms as in previous years; they are described in the Official and Tentative Methods of the Association of Official Agricultural Chemists, Fifth Edition, 1941, pages 642-3. The bacterial standards adopted for canning-grade sugar are based on the permissable number of thermophilic bacterial spores and are given for ready reference as follows:

Total Aerobic Thermophilic Spores shall not exceed 125 per 10 grams of sugar.

Aerobic Flat Sour Spores shall not exceed 50 per 10 grams of sugar.

Anaerobic Sulfide Spoilage Spores shall not exceed 5 per 10 grams of sugar.

Anaerobic Thermophilic Hard Swell Spores shall not be present in more than four of the six tubes of media inoculated with the test sample.

The method for determining the number of mesophilic organisms in the samples is as follows:

Aerobic bacteria. Twenty grams of sugar is weighed aseptically into a sterile 150 ml. Erlenmeyer flask marked to indicate a volume of 100 ml. Sterile distilled water is added nearly to mark. The sugar is dissolved by gentle shaking of the flask, and the volume is made up to 100 ml. Five ml. of the solution is distributed through 5 plates, which are then poured with dextrose-tryptone agar containing brom cresol purple indicator. The plates are incubated at 30° C. for 48-72 hours before being counted. Acid-forming organisms are identified by the production of a yellow zone around the colony, similar to that described for flat-sour type of thermophiles. The number of acid-forming organisms is included in the total count for each sample of sugar.

Yeasts and Molds: Five ml. of the same sugar solution is distributed through 5 plates as before. The plates are poured with standard wort agar and are incubated at 30° C. for 5 days before being counted.

On account of the relatively small number of yeasts and molds in sugar, difficulty is not often encountered when they are cultured together on plates.

Although standards have not been established for the number of mesophilic organisms in sugar, it has been suggested that the total bacteria

count should not exceed 100 per gram. Almost complete freedom from yeasts and molds is required of sugar to be used by the dairy and beverage industries.

The results of the examination for thermophilic and mesophilic organisms are given in Table I.

Sixty-nine samples were examined and eight, or 11.6% did not meet the specifications set forth for canning-grade sugar. Two samples, Nos. 4406 and 4439, are considered to be borderline samples, inasmuch as the flat-sour-type spore count exceeded the tolerance by only 10 spores.

Reference to the 1944 report shows that only four of 65 samples examined, or 6.2%, failed to meet canning-grade sugar specifications. Samples from the same factories also failed to meet canning-grade sugar specifications this year. Only one sample, No. 4413, contained an excessive number of hard swell-type spores; none contained an excessive number of hydrogen sulfide-type spores.

Five samples contained from 2 to 15 culturable yeast cells per gram. Only three samples examined during the previous year had more than two cells per gram. Molds were cultured from fourteen samples, or 20.2%, to the extent of 5 or more colonies per gram. This is in comparison with 11 samples, or 16.9%, last year.

The overall bacteriological quality of the composite sample is not as good as that of the previous year's sample. This does not mean that each sample contained more organisms than in 1943; some contained fewer and showed improvement in this quality factor.

EXAMINATION OF SUGARS FOR YEAST GROWTH-PROMOTING SUBSTANCES

The campaign-composite samples were examined for the presence and relative amount of substances which promote the growth of yeasts in

TABLE I

Bacteriological Examination of 1944 Sugars

	THERMOPHILIC BACTERIA				MESOPHILIC ORGANISMS			
	Aerobes		Anaerobes		Aerobic Bacteria		Yeasts	Molds
Sample Number	Total Count per 10 gm.	Flat Sour per 10 gm.	Sulfide Spores per 10 gm.	Hard Swell % Tubes With Growth	Total per 1 gm.	Acid-Forming per 1 gm.	Total per 1 gm.	Number Colonies per 1.0 gm.
4401	135	20	0	0	260	110	0	2
4403	0	0	0	0	34	11	15	2
4404	45	5	0	0	5	1	0	1
4405	5	0	0	0	4	0	0	1
4406	70	60	0	0	24	20	0	0
4407	40	20	0	0	13	2	0	0
4408	5	5	0	0	20	6	0	1
4410	10	5	0	0	15	4	0	0
4411	30	20	0	33	7	2	0	2
4413	245	150	3	83	41	31	0	2
4414	0	0	0	0	49	10	0	1
4415	40	10	3	0	11	8	0	1
4416	5	5	0	0	11	7	0	1
4417	15	0	0	0	14	7	0	2
4418	15	5	0	0	7	1	0	0
4420	45	15	0	0	117	95	0	1
4421	25	10	0	0	6	4	0	5
4422	10	0	0	0	50	18	0	28
4423	90	70	0	0	26	6	0	1
4425	40	15	0	0	19	7	0	2
4426	10	0	0	0	49	4	0	1
4427	10	10	0	0	36	2	0	5
4428	295	185	0	0	151	110	0	1

TABLE I CONT'D.

Bacteriological Examination of 1944 Sugars

	THERMOPHILIC BACTERIA				MESOPHILIC ORGANISMS			
	Aerobes	Anaerobes			Aerobic Bacteria		Yeasts	Molds
Sample Number	Total Count per 10 gm.	Flat Sour per 10 gm.	Sulfide Spores per 10 gm.	Hard Swell % Tubes With Growth	Total per 1 gm.	Acid-Forming per 1 gm.	Total per 1 gm.	Number Colonies per 1.0 gm.
4429	100	25	0	0	15	3	0	0
4430	20	10	0	0	23	9	0	1
4431	0	0	0	0	48	33	0	2
4432	0	0	0	0	23	7	0	2
4433	70	25	0	0	175	7	2	5
4435	25	0	0	0	34	3	0	2
4437	20	10	0	0	9	1	0	0
4439	70	60	0	0	35	15	4	15
4440	15	0	0	0	23	2	0	1
4441	0	0	0	0	13	1	0	1
4442	10	5	0	0	107	14	3	12
4443	60	20	0	0	18	7	0	1
4446	0	0	0	0	4	4	0	2
4447	30	15	0	0	10	7	1	3
4449	5	0	0	0	57	49	3	1
4450	35	30	0	0	14	3	1	2
4452	90	40	0	0	47	14	2	14
4453	0	0	0	0	21	6	0	1
4454	0	0	0	0	34	4	2	39
4455	95	95	0	0	12	5	4	2
4456	10	0	0	0	13	2	0	0
4456A	10	5	0	0	28	7	0	1
4457	20	0	0	0	37	33	1	1

TABLE I CONT'D.

Bacteriological Examination of 1944 Sugars

	THERMOPHILIC BACTERIA				MESOPHILIC ORGANISMS			
	Aerobes		Anaerobes		Aerobic Bacteria		Yeasts	Molds
Sample Number	Total Count per 10 gm.	Flat Sour per 10 gm.	Sulfide Spores per 10 gm.	Hard Swell % Tubes With Growth	Total per 1 gm.	Acid-Forming per 1 gm.	Total per 1 gm.	Number Colonies per 1.0 gm.
4459	0	0	3	0	3	1	0	14
4460	30	15	0	0	29	17	0	0
4461	5	0	0	0	8	4	0	1
4463	10	10	0	0	26	20	0	124
4464	10	0	0	0	25	22	0	1
4465	5	5	0	0	22	9	0	2
4466	55	45	0	0	11	11	0	1
4469	45	5	0	0	47	4	0	0
4471	20	0	0	17	3	0	0	13
4472	10	5	0	0	235	215	0	0
4473	5	0	0	0	10	5	0	1
4475	235	105	0	0	123	85	0	3
4476	0	0	0	0	9	4	0	0
4477	10	5	0	0	96	84	0	0
4478	15	15	0	0	30	26	0	2
4479	10	0	0	0	24	5	0	0
4480	5	5	0	0	36	23	0	1
4482	15	5	0	0	11	2	0	6
4483	35	25	0	0	15	4	0	0
4484	15	5	0	0	37	16	0	0
4494	30	0	0	0	16	6	0	15
4495	45	0	0	0	5	3	0	15
4496	10	0	0	0	63	15	0	4

solutions of the sugar. Information regarding the identification of these substances, their significance in beverages, and methods for estimating and reporting the relative amount in each sample was reviewed at length in the 1942 campaign report (Mimeographed circular AIC-29) issued in September 1943. Details of the method for estimating the relative amount of substance was repeated in the 1943 campaign report (AIC-62) issued in September 1944.

Results

The results of the examination of the samples are given in Table II in which the samples are arranged in numerical order of increasing yeast inoculum-multiple values. For your immediate information, the yeast inoculum multiple is obtained by dividing the number of yeast cells per ml. inoculated into the solution by the number per ml. after 72 hours' incubation at 30° C. The value 1.0 means that there was no multiplication of cells and that yeast growth-promoting substances are considered to be absent when determined by this method.

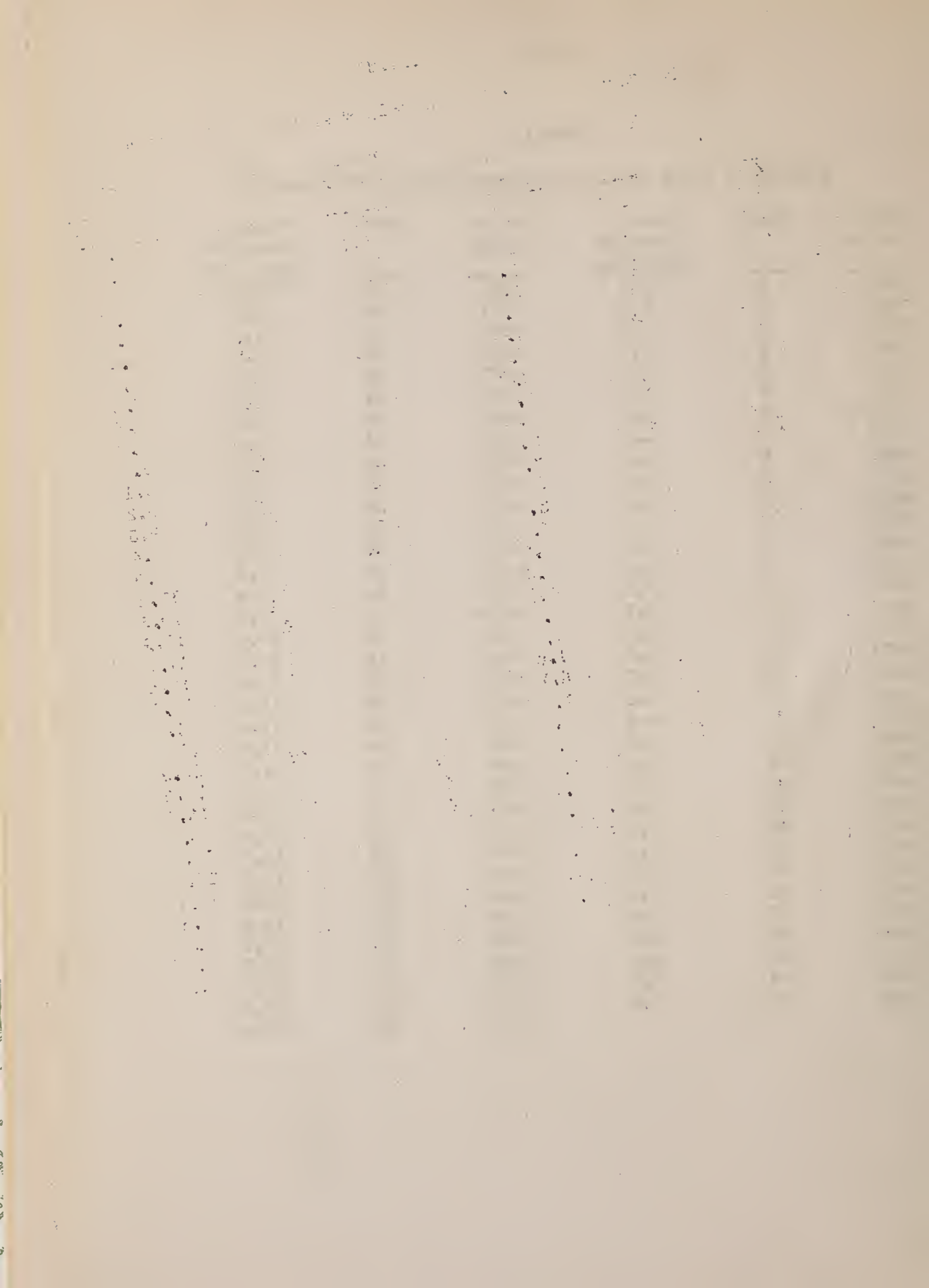
The samples are ranked according to the yeast inoculum multiple-values, the system of ranking having been changed this year by assigning the same rank number to those samples having identical multiple values. For example, the first five samples, which have multiple values of 1.0, are given the rank value one (1); sample No. 4417, which has a multiple value of 1.2, is given the rank value two (2); and so on.

The range of yeast inoculum-multiple values is from 1.0 to 22.9 and the average is 7.6. Although the maximum value obtained this year is lower than that obtained last year (33.8), the average value for this year is higher than that for the previous year (6.3). All of the sugars represented by these samples are considered to be well within the safe limits for use in the

TABLE II

Ranking of Sugar Samples Collected During 1944 Campaign

Sample Number	Rank	Yeast Inoculum Multiple	Sample Number	Rank	Yeast Inoculum Multiple
4403	1	1.0	4496	27	7.1
4411	1	1.0	4477	28	7.2
4426	1	1.0	4425	29	7.4
4449	1	1.0	4408	30	7.7
4482	1	1.0	4437	30	7.7
4417	2	1.2	4471	31	8.2
4456	3	1.3	4406	32	8.3
4459	4	2.0	4401	33	8.8
4432	5	2.2	4405	33	8.8
4420	6	2.6	4454	33	8.8
4423	6	2.6	4461	34	8.9
4447	7	3.2	4441	35	9.1
4466	8	3.4	4455	36	9.2
4453	9	3.8	4422	37	9.3
4476	9	3.8	4443	38	9.4
4484	10	4.1	4456A	39	9.9
4463	11	4.2	4439	40	10.4
4473	12	4.3	4450	41	10.5
4446	13	4.5	4428	42	10.9
4416	14	4.6	4429	43	11.3
4465	14	4.6	4433	44	11.4
4460	15	4.8	4479	44	11.4
4414	16	5.1	4495	45	11.7
4472	16	5.1	4452	46	11.8
4407	17	5.2	4404	47	12.5
4427	18	5.5	4480	48	12.8
4421	19	5.6	4435	49	13.0
4410	20	5.7	4442	49	13.0
4431	21	6.3	4494	50	13.2
4418	22	6.4	4475	51	13.4
4483	23	6.5	4464	52	16.3
4478	24	6.6	4469	52	16.3
4440	25	6.8	4415	53	16.5
4457	26	6.9	4430	54	17.3
			4413	55	22.9



manufacture of beverages.

GROWTH OF MOLDS IN HIGHLY CONCENTRATED SUGAR SOLUTIONS

Studies were continued of the growth of molds in highly concentrated solutions of sugar similar to those used in certain pharmaceutical preparations. It was previously observed that the mold Penicillium italicum ailed to grow when inoculated into 60-per cent solutions of some sugars, hile the extent of growth varied in solutions of other sugars. This indicated that there were apparently varying amounts of mold growth-promoting ubstances as non-sugar impurities in the different sugars.

Eighty-five samples of beet sugar from the 1942 and 1943 campaigns were made up in 60-per cent solutions, sterilized, inoculated with a suspension of mold spores, and incubated for 28 days at room temperature. The samples were arranged into three groups according to the extent of surface growth as follows: (1) no visible growth, (2) slight to moderate growth, and (3) heavy growth.

Two samples, or 2.3 per cent of the sugars, failed to support any visible growth; 20 samples, or 23.5 per cent, supported slight to moderate growth; and 62 samples, or 74.2 per cent, supported heavy growth. Correlation of these data with results of chemical analysis of the sugars did not indicate that a definite quantitative relationship existed between the known non-sugar impurities and the extent of growth.

It was observed, however, that one of the sugars which failed to support mold growth did not contain organic salts and that some of the other sugars which supported the heaviest growth contained the largest amounts of organic salts.